Theory, Politics... and History? Early post-war Soviet Control Engineering

Journal Item

Theory, politics ... and history? Early post-war Soviet control engineering

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A fascinating feature of post-war control engineering in the former Soviet Union was the rôle played by the study of the history of the discipline. Even before and during World War II some Soviet control scientists were actively researching the history of their subject; while after the war, historical studies played an important part both in technical developments and in legitimating a native Russian tradition. Two of the most important figures in this historical activity were A. A. Andronov and I. N. Voznesenskii, whose contributions are briefly considered.

Technological developments are always a complex interaction of theoretical, practical, political, social and economic influences. The post-war development of control engineering was no exception – particularly as the Cold War intensified – in both the former Soviet Union and in the West. One fascinating and highly idiosyncratic feature of the Russian context, however, was the rôle that the study of the history of the discipline played in its modern development. This article is devoted to a brief presentation and examination of this highly unusual phenomenon, which had its roots in the pre-war and wartime period, but became particularly influential in the late 1940s and early 1950s. Much of the material here derives from earlier papers by the author[1], but it is elaborated with further details obtained from archival research in 2000.

The pre-war context

During the 1930s control engineering in the former USSR was, as in most Western countries, highly fragmented. Various centres of expertise existed, where the control of sector-specific systems and processes was being developed: turbines, chemical processes, electrical machines, etc. Recognising the general importance of instrumentation and control, a Special Commission on 'Automation and Remote Control' was set up by the Soviet Academy of Sciences in 1934. The Commission held a conference on the subject in May 1935, and the journal *Avtomatika i Telemekhanika* [Automation and Remote Control] was established the following year. In addition to this predominantly industry-oriented activity, other research that turned out to be of enormous significance for control engineering was also being carried out in the context of nonlinear dynamics and the theory of oscillations. Of particular importance was the group led by A. A. Andronov in Gorkii (now, as in pre-Soviet times, known as Nizhnii Novgorod).

According to Andronov's biographer[2], he became interested in the history of control problems in the mid-1930s, in the context of applying Lyapunov-/Poincaré-based analysis techniques to a centrifugal governor affected by non-linear friction. The dynamics of a steam engine controlled by a centrifugal governor had been investigated by the St Petersburg engineer I. A. Vyshnegradskii at the end of the nineteenth century, who had come up with an ingenious graphical method for characterising the stability of a third-order linear system[3]. Over a period of some years Andronov and colleagues seem to have revisited the type of system analysed by Vyshnegradskii, armed with the new non-linear analysis techniques, although the work was not published until after the war. In 1940, Andronov met a Leningrad colleague, I. N. Voznesenskii, who was also interested in the history of the emerging discipline; indeed the papers he had published in the 1930s already demonstrated a familiarity with classical Russian work on the subject. Over the next decade the two were to collaborate in earnest, producing the first scholarly study of the history of control engineering.

Control classics

In 1945 Andronov wrote a long letter to Voznesenskii, in which he sketched out ambitious plans for historical activities. By this time Andronov had already written a biography of Vyshnegradskii for the publication *Outstanding Russian Scientists*, and was proposing that two scientific meetings should be held: one to consider Vyshnegradskii's work and the other to discuss the work of the French pioneers Farcot and Léauté. And most importantly of all, perhaps, he proposed celebrating the fiftieth anniversary of Vyshnegradskii's death by republishing the latter's two original nineteenth century papers on centrifugal governors as a 'control classic'.

According to Boiko, Voznesenskii and Andronov met three times between spring 1944 and autumn 1945 to discuss the 'control classics' project. By late 1945, discussions were ranging far beyond the Russian pioneer, and in particular they included the work of J. C. Maxwell and the Czech engineer A. B. Stodola, who had been a colleague of Adolf Hurwitz in Zurich in the 1890s – and who was responsible for attracting Hurwitz's attention to the stabil-

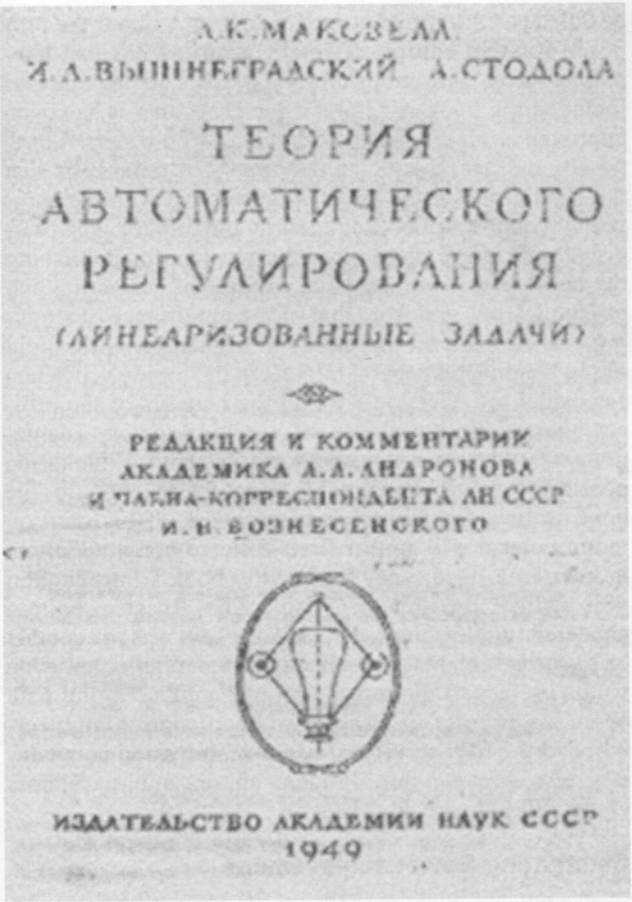

Fig. 1. Title page of Andronov and Voznesenskii's 1949 book.

ity problem.

It appears that the original idea was for several volumes, but the ultimate single output was the huge – and hugely scholarly – text *J. C. Maxwell, I. A. Vyshnegradskii, A. Stodola: the Theory of Automatic Control*, which appeared in 1949[4], three years after Voznesenskii's death *(Fig. 1)*. The 400 pages of the volume included the seminal papers of all three control pioneers (Russian translations of the English and German), together with critical assessment and analysis.

History is politics

Andronov's historical researches and writings coincided with an important shift in official attitudes towards the history of science and technology. Vucinich[5], in his history of the Russian Academy of Sciences, characterises this shift in the following way. From 1943-7 historians were particularly concerned with identifying and analysing Russian contributions to the world pool of scientific knowledge. Russian science was viewed as an important tributary of the mainstream of international science. In 1947-49 historians shifted their emphasis from the unity of world science to the distinctive attributes of Russian science. And finally, during the period 1949-52, historians were clearly discouraged from indicating inconsistencies and digressions in the professional work and general behaviour of the pre-Soviet leaders of Russian science. Rather, it was their patriotic duty to emphasise the pristine purity of natural science materialism in pre-Soviet Russia.

This political pressure was extremely deleterious for much of Russian history of science and technology. It was the time of spurious claims for Russian priority in every area of human endeavour, which, in some cases, even led to the ludicrous extremes of 'discovering' falsified historical artefacts. In January 1949 a notorious session of the Soviet Academy of Sciences was held on 'the history of national science', at which many excessive claims of Russian priority were made. Paradoxically, however, this climate actually seems to have been beneficial for the development of control engineering, and in particular for the development of the Russian approach that ultimately led to 'modern' or 'state-space' control theory.

The researches of Andronov and Voznesenskii meant that from the mid-1940s, the Russian, German and English work of the previous century was well known to groups in Gorkii and Moscow. In a recent interview with the author, Yuri Neimark, one of Andronov's doctoral students in Gorkii, recalled that the rediscovery and analysis of this classic linear theory was of importance to control theorists, as they tried to understand the relationship between stability, steady-state error, and so on. And the historical work also provided a framework for more modern approaches. For example, Neimark also recalls that after one trip to Leningrad, Andronov returned with information about the Nyquist criterion, and proposed that Neimark should investigate further the stability of linear systems. The result was what is known as the D-partition or D-decomposition approach, which could be presented as a generalisation of both the Nyquist and the Vyshnegradskii stability criteria. The historical researches

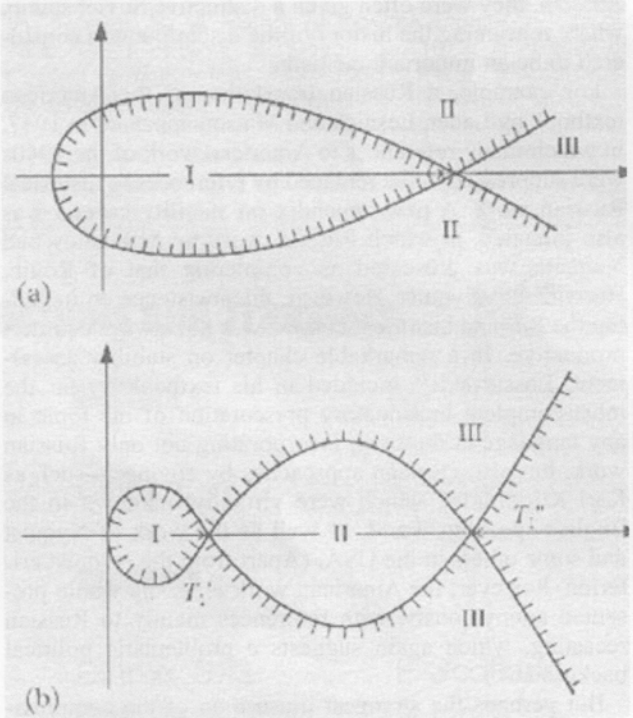

Fig. 2: Neimark's D-partition technique mapped polynomial roots in n-dimensional space to a two-dimensional complex plane. As one or two real system parameters were varied, different regions of this new complex plane could be associated with stability or instability of the original system. In retrospect, Vyshnegradskii's work of the nineteenth century could be seen as a special case of D-partition.

meant that control engineering could be legitimated as a subject with an impeccable Russian pedigree; and when combined with the other interests of Andronov and his groups in Gorkii and Moscow in non-linear dynamics, the

road to the application of Lyapunov methods to an increasing range of control problems was clear, and unlikely to be subject to political attack.

Andronov presented a paper on Vyshnegradskii to the 1949 meeting on 'the history of national science', a paper which was reprinted almost thirty years later to celebrate the hundredth anniversary of Vyshnegradskii's original paper. It is available in English[6], and remains an interesting contribution to the history of the discipline, showing very little evidence of the tendentious pseudo-history of the time. Indeed, in many ways it still stands up as a scholarly assessment of the significance of the work of Vyshnegradskii, clarifying the latter's modelling assumptions in the light of contemporary criticism of the approach.

Historical aspects of the late 1940s and early 1950s

If it can be argued that the historical interests of certain eminent Soviet control theorists in the 1940s had at least some positive influence on the development of the discipline in the former USSR, then the hardening political climate of the late 1940s and early 1950s meant that the transfer to the USSR of ideas of classical control as developed just before and during the war in the West was problematic. The late Yakov Tsypkin used to recall how he got into trouble simply through receiving a letter from American control engineers asking about his work! And when the first Western textbooks were translated into Russian, they were often given a distinctive Soviet stamp, where rehearsing the history of the discipline was considered to be an important element.

For example, a Russian translation of the American textbook by Lauer, Lesnick and Matson appeared in 1947, in which many references to American work of the 1940s were suppressed, to be replaced by references to historical Russian work. A new appendix on stability criteria was also included, in which Russian work by Mikhailov and Neimark was presented as completing that of Routh, Hurwitz and Nyquist. However, this insistence on including the Russian historical context was not always counterproductive. In a remarkable chapter on stability assessment, Lossievskii[7] included in his textbook by far the most complete introductory presentation of the topic in any language at the time, incorporating not only Russian work, but also German approaches by engineers such as Karl Küpfmüller, which were virtually unknown in the English-speaking world, as well as the work of Nyquist and some others in the USA. (Apart from the Nyquist criterion, however, the American work is on the whole presented anonymously, with references mainly to Russian recasting, which again suggests a problematic political background.)

But perhaps the strangest illustration of the complexities of the Soviet environment when dealing with historical topics is the appearance in 1951 of a Russian edition of a German classic work of the turn of the century. M. Tolle's *Regulation of Prime Movers*, first published in 1905[8] , was one of the most important early control texts in continental Europe, and Andronov was keen to produce a Russian translation in collaboration with M. Aizerman. Yet even in the early 1950s, such historical work was not without its political sensitivities. On 5 January 1950, in a letter preserved in the Moscow Archives of the Academy of Sciences, Aizerman wrote to Andronov about the proposed Russian edition of Tolle: "Smirnov has just telephoned from the publishers [...]. He said that he has included the book in the plan for 1950, that it has been approved at all levels, and that he now considers it both timely and necessary [...]. My personal opinion is that we should publish in spite of Kornilov's warning, providing you are still willing to write the preface. The preface should make quite clear the reasons for publishing the book, both from the point of view of correcting historical defects, and from that of the importance of studying classic work on the theory of regulation in the light of the heightened general interest in the topic [...]. When I consider the question I weigh the benefits of the project against the possibility of a critical outcry [demagogiya]". Aizerman goes on to write that he thinks the possibility of a 'demagogic' negative reaction to the book is low, for various reasons: work of his own on motor control will appear first; Tolle, although German, is now long dead; and, finally, the book's introduction will defuse possible criticism. The Russian edition appeared in due course: by 1951 the text was, of course, of historical interest only, but it is remarkable that even so the preface to the translation included a lengthy note about the priority of Russian work in control engineering, and the fifty additional pages of notes and commentary also stressed this. Prudent editors and translators could still not take any risks.

Celebrating Soviet achievement

The emphasis on the historical development of control engineering, particularly developments in Russia and the Soviet Union, was a significant feature of post-war activities by leading control theorists. Often this led to the downplaying or exclusion of foreign achievements, for political reasons. For example, an interesting little booklet was published in 1949 by Aizerman[9], apparently the text of a lecture. Entitled 'A historical outline of the development of governors and the theory of control', it virtually ignored the whole of classical control as it had emerged in the West, even though this was well-known by now in the Soviet control community.

The history of Soviet work was also kept in the foreground through the custom of publishing eulogies of major figures and institutions to celebrate important anniversaries. For example, a volume entitled *In Memory of Aleksandr Aleksandrovich Andronov* appeared in 1955, which included significant reference to his historical interests; while his 1949 paper on Vyshnegradskii was reprinted in 1978 to commemorate the centenary of the latter's work. In 1966 a special issue of *Automation & Remote Control* celebrated thirty years of what is now the Institute of Control Sciences, with a large number of articles addressing different aspects of control theory and technology. While much of the material in such publications is tendentious, it does seem to have played an important part during the later Soviet period in the culture of control engineering. It also meant that for a long time Russian control engineers and theorists were often much more aware of the history of at least some aspects of their discipline than were their western colleagues — at least until the classic works of Otto Mayr[10] and Stuart Bennett[11] appeared.

Conclusions

Russian control theorists were the first to investigate in detail the history of their emerging discipline, and although much of this work was prompted by historical curiosity, it also found a strong resonance in the scientific-political climate of the hardening Cold War towards the end of the 1940s. The fact that control engineering turned out to have an excellent native pedigree may well have strengthened the position of Soviet control scientists, particularly those working on applying Lyapunov methods to control problems.

The political importance of the history of science and technology also left its mark on the post-war generation of control textbooks in Russia. In some cases it acted to play down or even suppress Western work, while in others it encouraged authors to examine a much wider range of early control work than featured in textbooks of British or American origin.

The political climate of the late 1940s and early 1950s in the USSR made it very difficult for Russian scientists and engineers to engage in free debate of their own work and work from the West. It seems at least possible that the historical researches of Andronov and Voznesenskii were a liberating, rather than a restrictive, element in the development of control engineering in the former Soviet Union in the period leading up to the flowering of state-space methods.

Acknowledgments

The author's research in Moscow and St. Petersburg archives in 1997 and 2000 was funded in part by the exchange scheme between the British Academy and the Russian Academy of Sciences.

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Transfers to Graduate

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